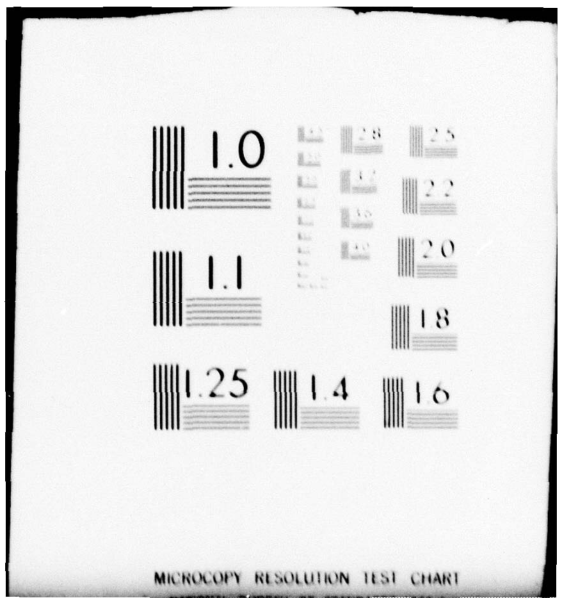
AD-A068 781 COLUMBIA UNIV DOBBS FERRY NY HUDSON LABS F/G 18/4
DESIGN AND CONSTRUCTION OF A SILICONE LIQUID SCINTILLATION COUN--ETC(U)
AUG 60 D SCHNABEL N6ONR-27135
UNCLASSIFIED TM-51 NL

| OF |

AD
A068781

END
DATE
FILMED
7-79
DDC


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

(15) N6onr-27135

(1a)

(6) DESIGN AND CONSTRUCTION OF A SILICONE LIQUID SCINTILLATION COUNTER*.

(14) TM-51

(11) 26 Aug 60

by

(12) 10p.

(10) Donald Schnabel
Columbia University, Hudson Laboratories
Dobbs Ferry, N. Y.

(9) Technical memo.,

* Columbia University, Hudson Laboratories Technical Memorandum-to-File No. 51, August 26, 1960.
This work was supported by the Office of Naval Research.

[redacted]

Toluene and other solvents used in liquid scintillation counters have traditionally caused problems in packaging. These problems led to the development of silicone oil as a scintillation liquid at this laboratory,[(1)] and the subsequent development of a large cylindrical scintillation counter. The use of silicone oil allows cast acrylics (e.g., Lucite, Plexiglas) as packaging substances. Such plastics are advantageous because they are easy to work, are relatively inexpensive, and have indices of refraction close to that of silicone oil.

The size of the container desired in our case was a cylinder 5 in. in diameter and 5 in. high. The thickness of the photomultiplier tube window or "light-pipe" (see Fig. 1) was roughly determined to be 2 in. for uniform pulse-height distribution. The light-pipes were machined from 3-in. sheet Lucite rather than from 5-in.-diameter rod because sheet Lucite has greater optical homogeneity and costs less per window. A commercially available cement* provided a sufficiently strong bond if the pieces to be bonded were dipped until soft, clamped tightly until the outside bead was dry, and then heat cured at 120°F for 2 hours.

Since the chamber desired was a field instrument and subjected to a temperature range of 30-90°F, the large coefficient of expansion of the scintillant oil (11 cc of differential volume over a 16.6 Centigrade degree range)

---

* Rez-N-Bond, Schwart.. Chemical Co., Inc., 50-01 Second Street, Long Island City, N. Y.

required an expansion chamber.* Preliminary tests with a spring-loaded plunger with O-ring proved unsuccessful. Also discarded was the use of a diaphragm of some sort. The lack of success of these methods was due in part to the incompatibility of rubber with the scintillation liquid being used. The method finally adopted was to machine a triple-hole expansion chamber into the window (see Fig. 1). This provided a 25-cc volume from which nitrogen gas and vapours could return to the solution upon heating and thus relieve pressure buildup in the cylinder. The 3-hole configuration was used instead of a single large-diameter hole to preserve the light-pipe characteristics and structural strength of the window. A 4-mm i.d. air outlet hole was provided to permit total filling and facilitate outgassing. Stainless steel plugs with Teflon gaskets sealed the holes.

Owing to the fact that at low temperatures naphthalene crystallized out of solution and attenuated light pulses, it was necessary to revise the recipe for the liquid scintillant developed by Miranda and Schimmel. It was determined that a mixture of 4 grams of 2,5-diphenyloxazole plus 65 grams naphthalene (recrystallized from alcohol) per liter of Dow Corning Silicone-555 fluid was most suitable. As reported by Miranda and Schimmel, the naphthalene concentration was not critical; thus the pulse-height efficiency was not appreciably altered.

---

* This is equivalent to a .05 percent change in volume per Centigrade degree.

Before filling the cylinders the liquid was flushed with aged dry nitrogen for 30 minutes and heated to 100°F.* The containers were then filled, evacuated to 1 cm of Hg for 20 minutes, and sealed. The units were always positioned in the field with the expansion chamber sector uppermost.

The similarity of the index of refraction of cast acrylics to the silicone oil permits the use of an external rather than internal reflective coating. The commonly available coatings, magnesium oxide and titanium oxide, are generally used in loose powder form packed around the chamber, or as pigments in a painted coating. (DuPont manufactures a "High Reflectance White" paint, No. 29-915, which is believed to be such a pigment.) It was difficult, however, to apply the loose powder to a large surface, and previous experience had shown that the paints scale and discolor with age. Various attempts to bond these oxides to Lucite had not proven successful. Brazilian quartz backed by aluminum foil was therefore considered as an alternative.

It was anticipated that a fine-mesh Brazilian quartz would act as a good diffuser of light. The index of refraction of Brazilian quartz, quite different from that of Lucite, leads one to expect both refraction and reflection of an incident light-ray at each interface. In addition, the fine transmission characteristics of Brazilian quartz in the near-ultraviolet region lead one to expect little attenuation of the refracted portion of the light. A fine-mesh quartz provides many interfaces for the diffusion of light; however, care must be taken, with so many interfaces, to insure a minimal loss of light by removing all foreign matter. It

* To remove traces of dissolved oxygen and water vapour.

was also thought that an aluminum foil backing would act as a good reflector.

Moreover, it was indicated that Brazilian quartz would be sturdy, would not deteriorate with time, and would bond well to acrylics because of its crystalline structure. A comparative test performed initially with 1-in. (diameter) by 1-in. cylinders and finally with the 5-by-5 cylinders themselves showed this to be so. The substances tested were: a high-reflectance white paint, titanium oxide suspended in an acrylic-base adhesive, aluminum foil, and Brazilian quartz suspended in various adhesives. The tests were conducted using the above substances alone and then in different combinations. Two coats of Brazilian quartz suspended in a methyl-methacrylate monomer base adhesive* and backed with aluminum foil† was empirically determined to be the most efficient reflective coating (see Fig. 2).

The Brazilian quartz is cleaned in the following manner: prepare a tray of about 750 ml of strong boiling solution of Sparkleen‡ and distilled water, adding about 30 g of 325 mesh Brazilian quartz; stir for 5 minutes while heating; remove from heat; allow the solution to settle for 5 minutes and decant; rinse seven times repeating the above steps with about 750 ml of distilled water each time; allow to dry under cover to prevent dust from settling into the tray. The mirror-like side of the aluminum foil is cleaned three times with acetone and then with a Sparkleen and distilled water solution followed by three rinsings.

---

* H-94, Schwartz Chemical Company.

† The heavy-gauge variety available in any grocery store is quite adequate.

‡ A laboratory detergent sold by Fisher Scientific Company.

The cylinder was cleaned three times with methyl alcohol to prepare the surface for coating. A slurry of the clean Brazilian quartz and the monomer base adhesive was prepared. This was maintained at approximately the consistency and color of skimmed milk during the coating process by adding the ingredients as necessary. The slurry was then applied with a clean brush and allowed to stand until dry (about 15 minutes). This coating was then covered with the previously cleaned aluminum foil. The cylinders were completely wrapped in 1/8-in. foam rubber as a precaution against wear.

Under field conditions, cylinders prepared as described in this paper have been used for over a year without any ill effects being noted.

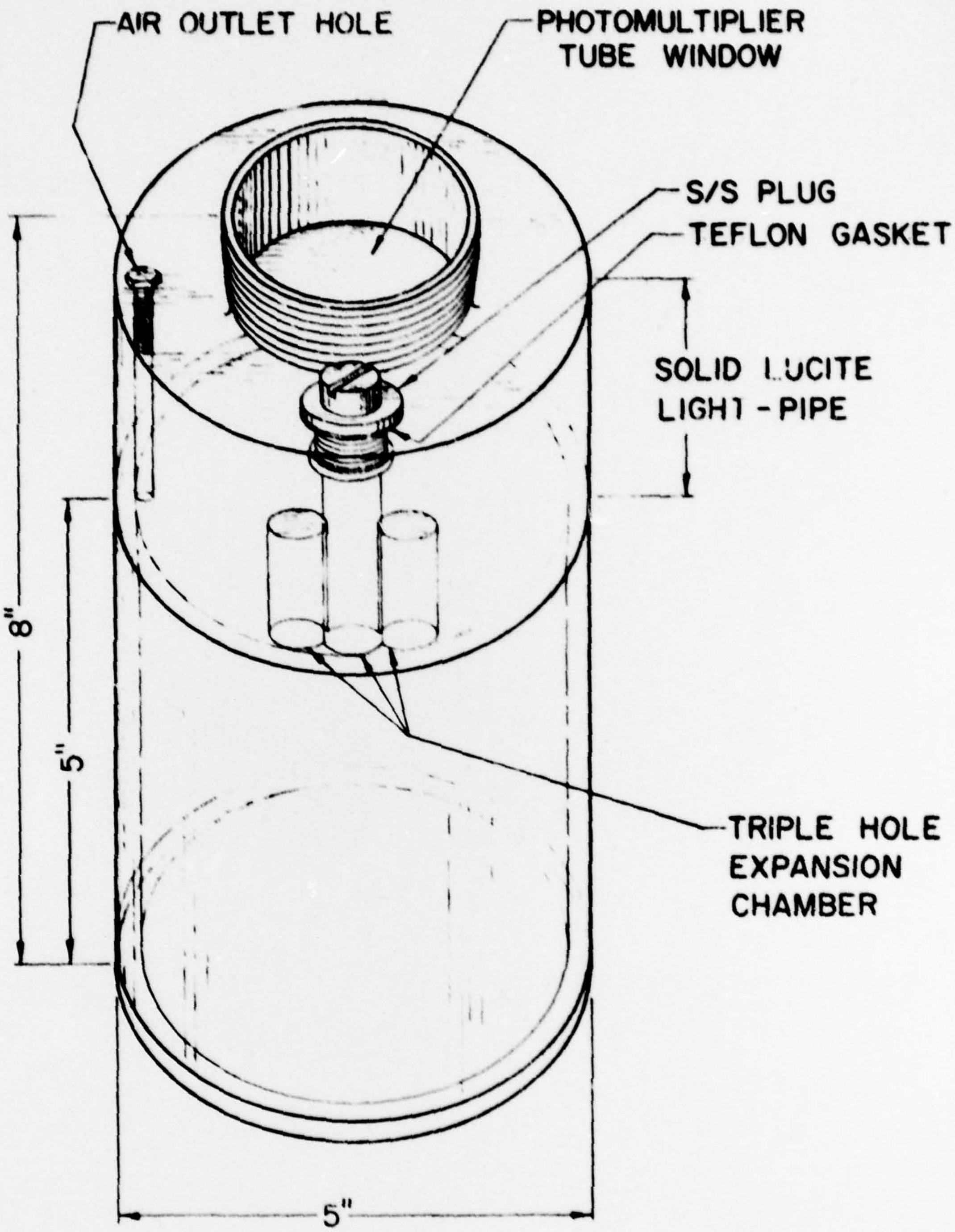


Fig. 1 Liquid Scintillant Container

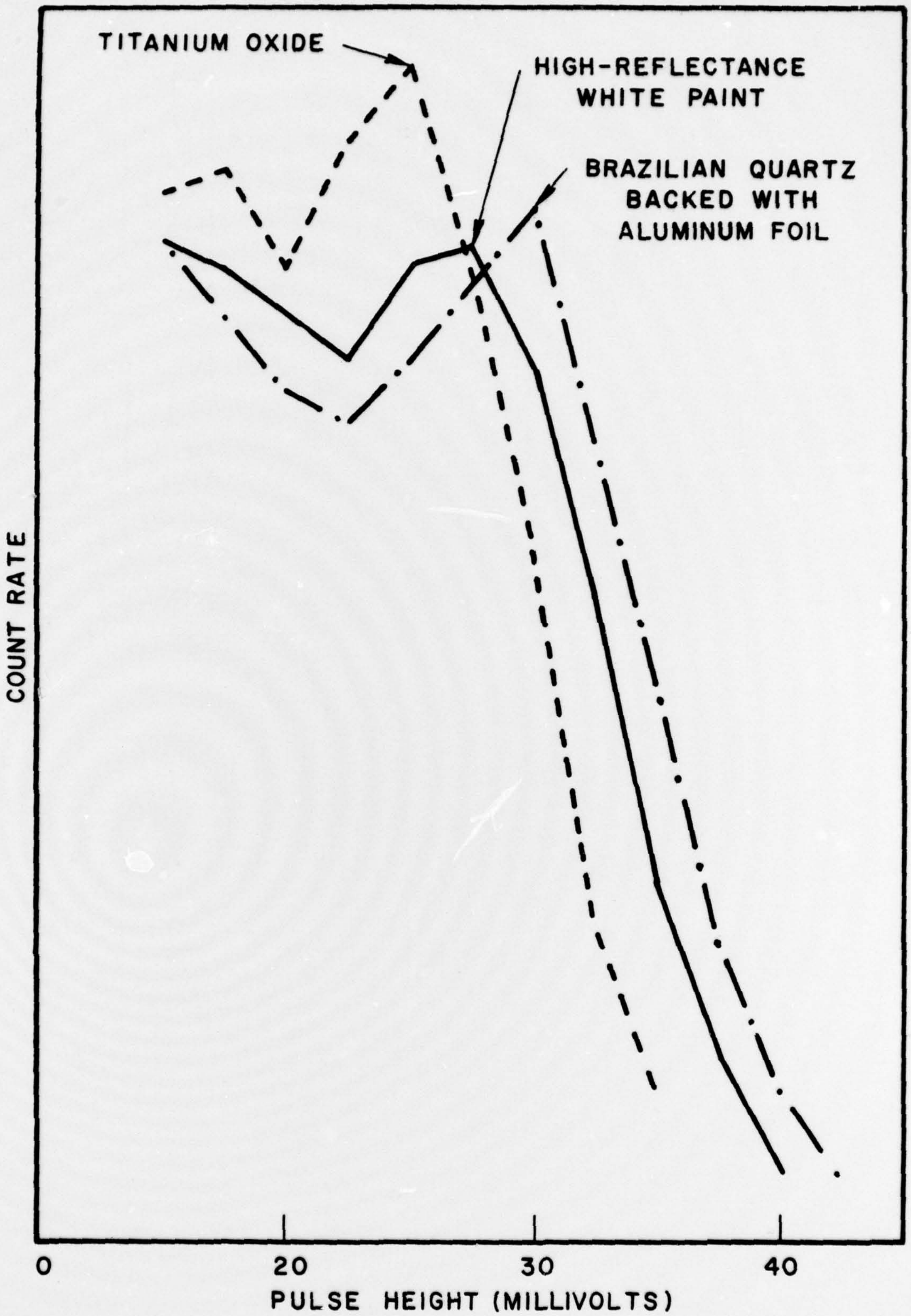


Fig. 2 Cesium^{137} Spectrum for Various Reflective Coatings

REFERENCE

1. H. A. Miranda, Jr., and H. Schimmel, Rev. Sci. Instr. 30, 1128 (1959).